INTERPOSER CONNECTORS WITH MAGNETIC COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This disclosure claims priority of U.S provisional patent application No. 61/655,483 filed on Jun. 5, 2012 and U.S provisional patent application No. 61/786,037 filed on Mar. 14, 2014 and U.S non-provisional application 13/105091 filed May 11, 2011 which claims priority to U.S provisional patent application 61/395,479 filed May 13, 2010, all of which are incorporated herein by reference in their entirety.

COPYRIGHT NOTICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This disclosure deals with electrical connections between electronic devices in which electrical continuity is maintained through magnetic attraction.

2. Description of Related Art

There are many kinds of electrical connectors that are used to provide electrical signal and electrical power from one device to another. Many conventional reversible connectors depend upon overcoming a mechanical force during the mating process in order to provide a residual biasing force between the electrical contacts. Other zero-insertion-force or ZIF connectors, such as those for flat cables (as expected by the name) allow cable contacts to easily slip into position. However, a mechanical force still needs to be applied to create or release contact pressure after the insertion phase. Typically, in order to mate one electrical connector to another device, the two connectors must be oriented within a small range of angles and directed along a mating path within a certain displacement tolerance range. It is fairly easy to connect a USB connector to a mobile phone jack when the male and female members can be observed. This can be difficult in applications in which connectors are hidden in a cavity, such as a protective case for the electronic device. Guiding ramps and floating mechanical assemblies have been employed to ease these difficulties, but this usually increases the size or cost of the assembly.

Some connectors have arrays of fragile pins that can be damaged if not properly aligned, or spring contacts that relax overtime and become less reliable through use.

While some systems attempt to address one or more of these problems, a need still exists for an electrical connector solution that provides a robust electrical and mechanical attachment using magnetic materials. This disclosure is directed at addressing one or more of these difficulties. Other goals of some embodiments are to provide protection of the standard device I/O connector; to provide breakaway capability of attached devices, to facilitate installation of devices into protective cases and to provide a system for providing an adapter to provide device attachment flexibility.

BRIEF SUMMARY OF THE INVENTION

The interposer electrical connector systems and methods described below contain magnetic elements configured to provide any of the following capabilities: self-mating contact forces, protection of device connector structures from dust or moisture, low-profile design, relatively large dimensional tolerances insensitivity than the standard I/O connectors, mechanical flexibility, conformability to curved surfaces, articulated construction designs, and self-aligning electrical contacts. In some embodiments, flexible magnetic interconnects described in co-owned U.S. Pat. No. 8,187,006 are used to provide some of these benefits. Some embodiments include multiple permanent magnets with the same magnetic pole aligned toward the connector interface. Some embodiments include magnetic flux concentrators or pole pieces that direct the magnetic flux circuit to increase electrical contact forces. Some embodiments comprise a single magnet per mated contact pair that provides a plurality of electrical connections.

In a broad sense, an "interposer" means "something that is placed in between (two other things)." For the purposes of this disclosure, the term "interposer electrical connector system" should be interpreted as an electrical connector system that can be configured to be placed between two electronic devices; each device already having existing connectors and also more broadly as an electrical connector system that is placed between two electronic circuits. The embodiments disclosed focus on the magnetic connector embodiments that are located "in between", not on the presence or absence of conventional connectors away from the interposing connection. A connector system that is suitable for interposer use may also have characteristics that match requirements for certain standalone applications, and unless claim terms specifically restrict the application, the broader interpretation should be applied. In this disclosure, the singular term "interposer electrical connector" or "interposer connector" refers to one of the mating halves of an interposer electrical connector system.

Some embodiments include compliant contacts and flexible circuitry. In embodiments of the methods and systems disclosed herein, the compliant contact may be comprised of a metal foil or wire. The term "flexible circuit" (also called "flex circuit" or "FPC"), as used for purposes of this disclosure, includes flexible printed circuitry having electrically conducting lines on electrically non-conducting flexible substrates and electrically conducting flexible members such as metal foils or flexible films which include electrically conducting fillers such as carbon or metals. Embodiments that describe one type of flexible printed circuit should be understood to also illustrate embodiments in which any other type of flexible circuit is substituted for the printed flexible circuit. Embodiments that describe a flexible circuit that is not a flexible printed circuit should be understood to also illustrate embodiments of any other type of flexible circuit including flexible printed circuits. In many embodiments, the distance between magnetic structures is determined in part by the thickness of contact pads on an insulating substrate. The term "contact pad" typically refers to the area of a printed circuit in the vicinity of where something is attached or connected to conduct electrically. In this disclosure, contact pads are formed in some embodiments on flexible printed circuits, while other embodiments include contact pads formed on rigid printed circuits. As used herein for the purposes of this disclosure, contact pads should be interpreted as synonymous with "contact"; thus, contacts and contact pads may be created without using printed circuitry techniques.

When thinness is important, even rigid or brittle substrate materials may become "flexible". In this case, a flexible printed circuit in a description may be constructed from materials that are not flexible in bulk form, or the flexibility may have no functional benefit beyond thinness. For a flexible